UNIVERSITY OF WYOMING REMOTE SENSING LABORATORY

PROGRESS REPORT No. 4
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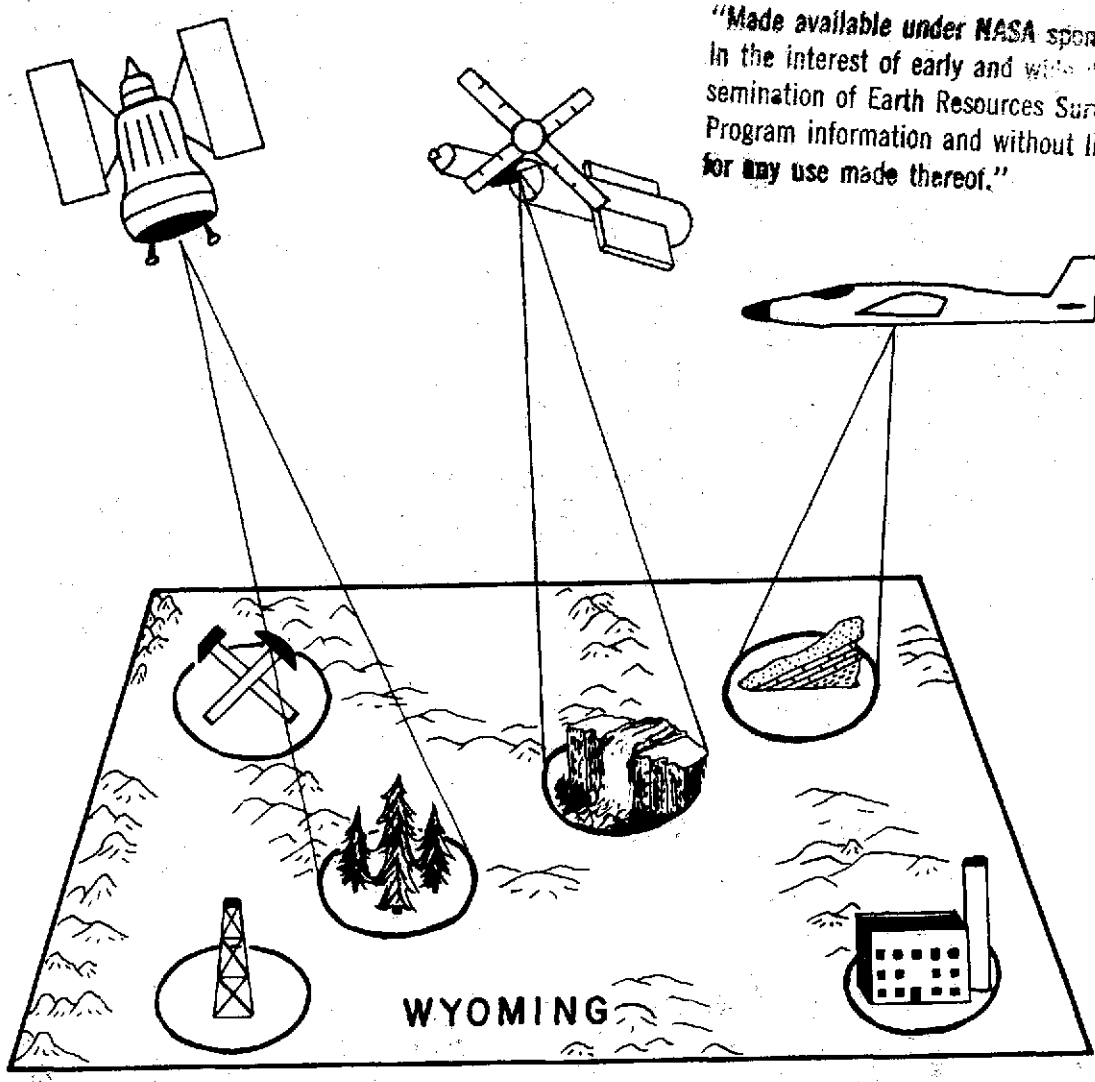
RONALD W. MARRS



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16. Abstract

Application of EREP S-190 photography currently under study include: 1) a re-evaluation of Wyoming tectonics using ERTS, EREP and aircraft photography, 2) comparisons of ERTS, EREP, and aircraft imagery for general geologic mapping and land-use mapping 3) continued efforts to map alteration color anomalies from EREP data and 4) range-land mapping and biomass estimation with EREP S-190A photography. Image enhancement procedures are being applied in some of these studies. Repetitive coverage is used as a means of reducing illumination-angle bias in tectonic studies.

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Figure 2. Technical Report Standard Title Page

PROGRESS REPORT 4 - MULTIDISCIPLINARY STUDY OF WYOMING TEST SITES

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EREP Progress Report IV

CONTRACT OBJECTIVES

Objectives of the Wyoming EREP investigation include research into applications of EREP data to hydrologic, biologic, geologic, geothermal, and land-use problems. Because most data users are limited to visual analysis of satellite data, major emphasis is placed on applications which can be accomplished through visual techniques. Enhancement procedures are restricted, as much as possible, to techniques which employ simple and relatively inexpensive equipment. More sophisticated laboratory analyses and computer techniques are employed for reference determinations and as special-purpose enhancement procedures.

Contract objectives have recently been modified by an addendum to the "Statement of Work". This addendum specifies that work be directed toward a determination of the value of high-resolution space imagery by specific comparisons with ERTS imagery and aircraft data. These comparisons are to include applications in analysis of photolinear elements, geologic mapping, and land-use mapping.

OVERALL STATUS

The initial phases of the Wyoming EREP investigation has fallen behind the investigative schedule set forth in the "Milestone Plan" (Marrs, 1973c). This delay resulted from delayed launch and belated receipt of EREP data. Time schedules for the various individual studies have been postponed in accordance with the starting delays so that investigative expenditures could be reduced to a minimum until adequate data were made

available. Currently both investigative progress and expenditures are approximately five months behind schedule. Appropriate contract extensions have been discussed with the Principal Investigations Management Office. We anticipate that the original research objectives will be realized with minor budget changes reflecting rescheduling in response to delayed investigations. We are particularly concerned with field checks of work that is to be completed after September, 1974. Such checks are an essential element of the investigation, but will require extension of the EREP contract through the 1975 field season. A budget increase has been requested to cover the additional work stipulated in the "Addendum to Statement of Work" (May 16, 1974).

Appropriate data for the S-192 and S-191 applications are not yet available; consequently, those portions of the investigation dependent upon these data have been delayed pending receipt of the necessary data.

Some S-190A and S-190B data have been received for SL-2, SL-3, and SL-4 data passes along seven different ground tracks (19, 5, 62, 48, 45 59, and 16). Prints, transparencies, and negatives were requested for each of the EREP passes over the Wyoming site. Many of these data sets are incomplete; and, for some SL-4 tracks, we have not yet received any photographic data. Table 1 summarizes the photographic data products still needed in support of this investigation:

*Items checked (X) are needed

TABLE 1. EREP DATA NEEDS*

Mx	Pass	Rev	Track	Date	9" Trans	9" Print	41/2" Trans	roll and frame nos.	9" Trans						9" Print						70mm pos						70mm neg						roll and frame nos.	S-192 Screening Film
									clr	CIR	grn	red	IR1	IR2	clr	CIR	grn	red	IR1	IR2	clr	CIR	grn	red	IR1	IR2	grn	red	IR1	IR2				
2	6	374	19	6/9/73		X		81(147-160)							X	X	X	X	X	X											9,10,(111-124)7,8,11, 12(103-116)	
2	8	403	48	6/11/73	N.A.	N.A.	N.A.	not available	X	X	X	X	X	X													X	X			15,16,(009-013)13,14, 17,18(009-013)	
2	10	431	5	6/13/73		X		82(136-158)			X	X	X	X	X	X	X	X	X	X											15,16(220-239)13,14,17, 18(203-222)	XX
3	2/13	1184	48	8/4/73	X	X	X	83(30-36)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	21,22(102-107)19,20,23, 24(102-107)	
3	4/15	1198	62	8/5/73	X			83(184-196)																							21,22(214-223)19,20,23, 24(214-223)	
3	20/31	1720	16	9/10/73				85(389-390)								X			X								X	X			39,40(53-55)37,38,41, 42(53-55)	
3	26/37	1749	45	9/12/73				86(334-337)																					X	X	39,40(152-154)37,38,41, 42(152-154)	
3	28/39	1763	59	9/13/73				88(013-023)																							39,40(199-215)37,38,41, 42(199-215)	XX
3	32/43	1791	16	9/15/73				87(122-123)																			X	X			39,40(340-345)37,38,41, 42(340-345)	
4	30/85	3598	19	1/18/74	X	X	X	92(160-168)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	69,70(144-154)67,68,71, 72,(144-154)	
4	35/87	3641	62	1/21/74	X	X	X	92(261-280)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	63,64(355-364)61,62,65, 66(355-364)	
4	37/88	3655	5	1/22/74	X			93(119-137)	X	X	X	X	X	X	X	X	X	X	X	X											64,70(238-252)67,68,71, 72(238-252)	XX
4	41/92	3697	2	1/27/74	X	X	X	?	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	?	XX

WORK SUMMARY

The contract period from March 1 to August 1, 1974 saw continued progress in the elevation of EREP photographic sensors for 1) general geologic mapping 2) regional tectonics and structure, 3) mineralization and alteration mapping 4) land-use mapping, 5) green biomass estimates and 6) identification of high-selenium lithologic facies. Emphasis has been on general geologic and tectonic applications with particular attention being given to direct comparisons of capability of ERTS, EREP and aircraft sensors.

Early results of these efforts were reported at the April, 1974 meeting of the American Geophysical Union; the American Institute of Mining and Metallurgical Engineer's Mineral Symposium (May 9-11); and May 19 meeting of the Wyoming Geological Association and the June meeting of the American Association of Petroleum Geologists, Rocky Mountain Section. A paper entitled "Evaluation of EREP Data in State Resource Mapping" was presented at the August meeting of the American Astronautical Society in Los Angeles, California, and an exhibit featuring Skylab and other Earth Resources Remote Sensing Programs has been prepared for display by the University of Wyoming at the Wyoming State Fair (August 26-30).

A more comprehensive summary of these studies comparing ERTS and Skylab in different geological applications was submitted as a special report under contract NAS 9-13298, in J-ne, 1974 (Houston and others, 1974). Special reports on other aspects of the Wyoming EREP program will be submitted as these studies are completed.

General Geologic Mapping: Five individual studies have been initiated for evaluation of EREP photography for general geologic mapping. Three of these are now complete and the others should be completed within three months.

In a study employing EREP-S-190B photography for mapping of Tertiary and Cretaceous units exposed in the Powder River Basin and Black Hills, it was discovered that the major lithologic contacts were generally coincident with photomap unit contacts and that some additional subdivisions were detectable for some units. However, some of the accepted formations could not be distinguished because of lack of contrast with adjacent units and masking by vegetation. It was also noted that many outcrops of reddish-colored baked shale were recognizable, but that the utility of the EREP photography for mapping these was dependent upon the degree of oxidation or the intensity of red coloration in the baked strata.

The tentative conclusions of this study were presented in a previous progress report (Marrs, 1973c, p. 13-16). Subsequent comparisons of the photomaps with available field data confirmed these conclusions, thus indicating a definite potential for regional photogeologic mapping with the EREP S-190B photography. Determination of the potential for more detailed mapping was left to other project investigators working in areas where the detailed geology is of greater significance.

A similar study in the Green River Basin was somewhat more successful (Marrs, 1973c, p. 16-21). Here, the relatively sparse vegetation allowed better distinction of subtle tonal contrasts between lithologies.

Nevertheless, the similarity of some of the Tertiary sedimentary units was such that they could not be distinguished. Other units were readily divisable into subunits on the basis of the EREP photo-interpretations.

Some success in these regional mapping programs prompted attempts to employ the EREP photography in local, more detailed studies. One such study is aimed at mapping sand/shale facies changes within the Wasatch sedimentary units overlying the Roland coal seam of the Powder River Basin. This study may prove particularly interesting because the sand/shale facies changes appear to bear a direct relationship to selenium concentrations in the soils and to the distributions of toxic species within the plant community. The selenium distribution is of interest not only because it affects the range capability but also because it could severely degrade the quality of surface and subsurface waters if proper precautions are not taken when the Wasatch overburden is removed prior to mining the coal. A thorough understanding of the distribution of the selenium rich units may prove essential for sound mining procedures.

The facies mapping study was begun by detailed analyses in a small test area adjacent to a large, active coal mine. Color infrared aerial photography (1:24,000 and 1:120,000) was used in the initial mapping program. Correlation of the photomaps with field geologic data, geochemical analyses of soil samples, and plant communities demonstrate that the selenium rich sand lenses within the Wasatch formation can be delineated using the aerial photograph. Initial attempts to use Skylab S-190B color photography instead of aerial photography have been

encouraging. The larger sand-lenses are distinguishable on the EREP photography, but the smaller lenses and the very intricate interfingering of the sand/shale facies have not yet been successfully defined because of the resolution limitations of the duplicate S-190B photographs. High-resolution transparency enlargements of the EREP S-190B coverage have been requested with the hope that additional detail will allow interpreters to map many of the more intricate patterns of facies change.

A fourth study in general geologic mapping with EREP photography was recently completed for the Horn Area of the Bighorn Mountains. The results of this study are discussed in a recent special report (Houston, and others, 1974, p. 14-27). Comparison of the relative utility of ERTS, EREP, and aircraft imagery was a major objective of the Horn Area mapping program. The resulting maps show a distinct advantage of higher resolution in geologic mapping. EREP provides more information than ERTS and the aerial photography allows for still more improvement on parts of the geologic map. Yet, many areas can be adequately mapped without the great detail provided by aircraft sensors. The Horn study demonstrates the advantages and disadvantages of each type of data. ERTS imagery was used in making a regional map at 1:250,000. Spot checking in the field showed that the ERTS interpretation was sufficiently detailed in some areas (generally the areas of least complexity) but produced a very poor representation of the geology in some structurally complex areas. An interpretation of Skylab S-190B photography (enlarged to 1:125,000) in one area of complex folding and faulting produced a much improved photogeologic map. A reinterpretation of the central portion of this area at 1:62,500 from aerial photography produced still more geological

information and a somewhat different structural interpretation. Finally, field investigations confirmed much of the interpretation but resulted in still further modification of some parts of the map. The additional information obtained through each successive technique suggests that the best map would result from detailed field mapping of the area. But the critical consideration is the efficiency of the mapping program. Each successively higher resolution technique requires that a greater number of photographs be obtained and interpreted and more interpretation time. Consequently, the synoptic, high-altitude coverage should be used for regional mapping and in areas of least complexity. This coverage should be supplemented by more detailed coverage as needed. EREP photography yields a synoptic view comparable to that of ERTS while providing detail intermediate between ERTS imagery and aerial photography.

Linear Features and Regional Tectonics: An early comparison of dominant trends in linear features of the Beartooth Mountains, Northern Bighorn Mountains, and Powder River Basin illustrated both the potential of EREP for tectonic studies and the effects directional illumination for feature enhancement (Marrs, 1973c, p. 8-10). A more intensive study of linear features in the Precambrian terrane of the Wind River Mountains addressed the problems of detail (high-resolution) in mapping linear features and the influence of illumination angle (Houston and others, 1974). Conclusions were: 1) repetitive coverage (with various sun elevations and azimuths) is needed for reliable mapping and analysis of linear features, 2) synoptic coverage is essential to recognition of large, regional linear features, and 3) increase resolution allows a greater number of linear features to be detected. Consequently, it is apparent that

synoptic coverage with the highest possible resolution should be gathered repetitively by a non sun-synchronous sensor system in order to obtain the maximum amount of information regarding linear elements.

The capability of the University of Wyoming Remote Sensing Laboratory has recently been increased with the addition of a video edge-enhancer system to the array of image analysis equipment. Initial work with the system indicates that it will be of particular value in analysis of photo linear features. With this new capability and the background provided by the completed tests, we are now initiating a re-evaluation of the regional tectonics of Wyoming using available ERTS and EREP imagery as a chief means of defining "possible" tectonic elements. The study will incorporate the best published information and field data as a means of evaluating the interpretations derived from the satellite imagery.

Mineralization and Alteration: Two separate attempts were made to locate possible mineralized areas by direct photointerpretation. Copper mineralization in the Absaroka volcanic province is known to be associated with the color anomalies that reflect intense alteration of the volcanic rocks. Efforts to locate and define these color anomalies on color and/or color infrared EREP photography were largely unsuccessful (Marrs, 1973c, p. 27). Several interpreters were asked to locate any strong color anomalies visible on the EREP color infrared photograph of the Absarokas region (Fig. 1). Each interpreter located several anomalies, but the located areas were strikingly different. Figure 2 is a typical comparison of the results obtained by two interpreters.

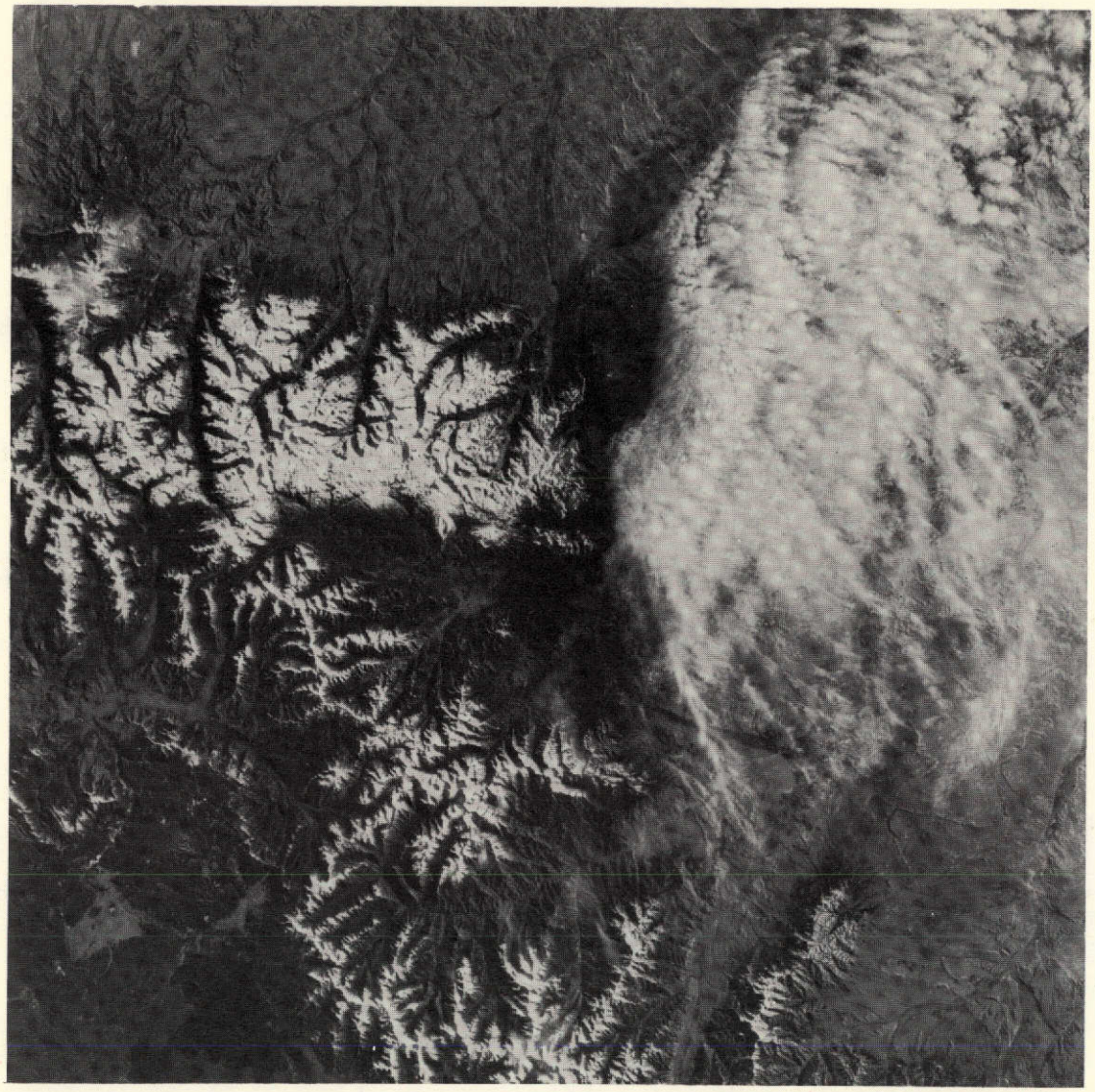

Figure 1. Skylab S-190A photograph of Absaroka Range and Beartooth Mountains, Wyoming and Montana (Frame 225, Roll 15, Track 5, EREP Pass 10). This area was used as a test area in an attempt to map alteration associated with possible porphry copper deposits.

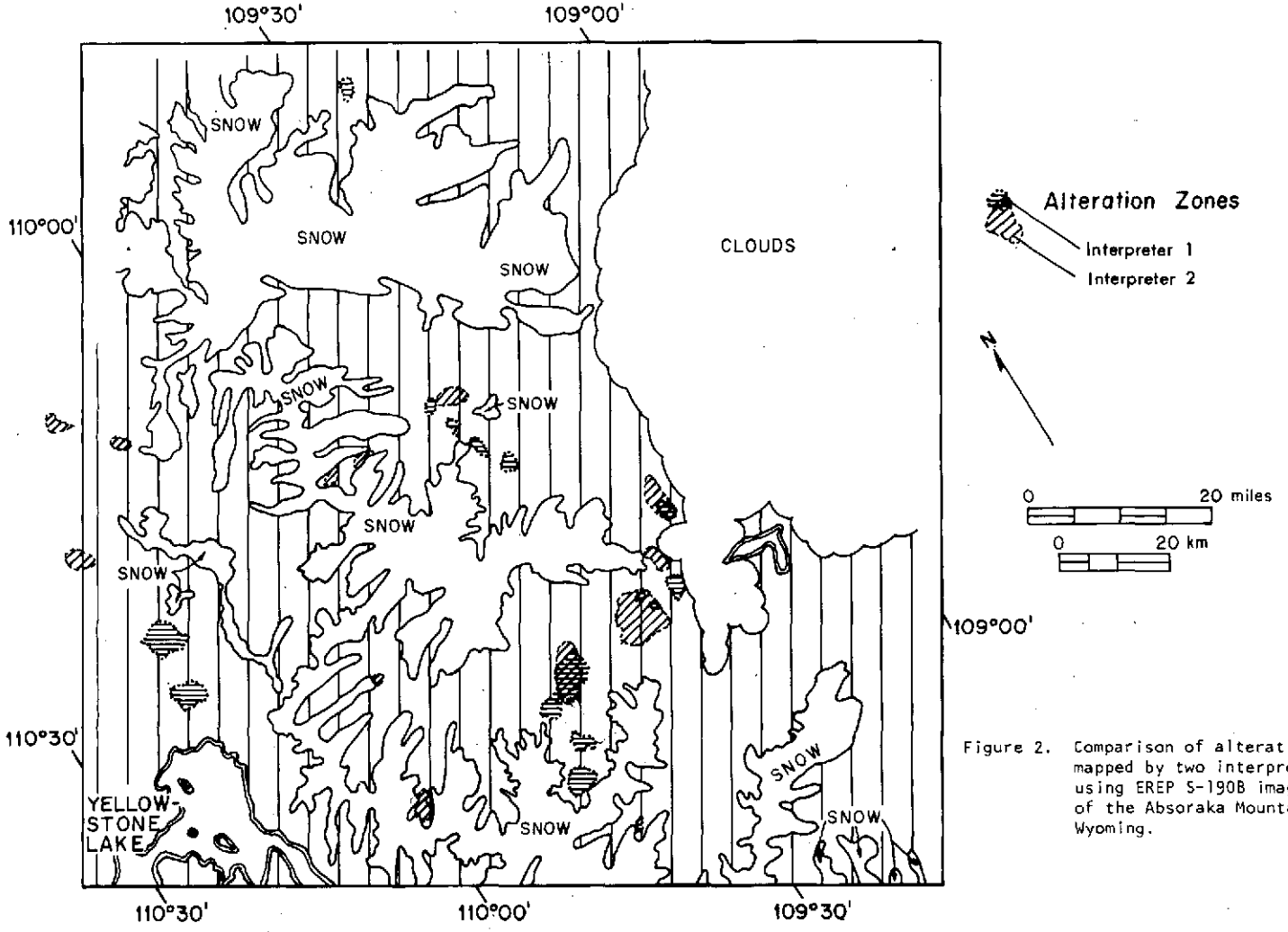

Figure 2. Comparison of alteration zones mapped by two interpreters using EREP S-190B image 15-225 of the Absoraka Mountains, Wyoming.

Interpreter 1 defined 16 "possible" zones of alteration. Interpreter 2 located 12. Only four of the alteration zones were located by both interpreters.

A similar attempt to map altered areas associated with uranium mineralization in the Powder River Basin met with similar results. Alteration maps from ERTS and EREP image interpretations (Fig. 3 & 4) were compared to a map of the known area of alteration (Fig. 5). All were in agreement of the general area of alteration, but the boundaries of the areas mapped showed little correspondence. The effort was judged "unsuccessful" because the areas of greatest interest, the alteration fronts, could not be reliably located. Nevertheless, the investigators feel that the EREP interpretations have some utility because some of the mapped areas do include areas of known alteration and mineralization. Therefore, the interpretations may be useful as a tool for isolating areas of interest to be studied further by more definitive methods. It may also be possible to process the images in some way to enhance the color anomalies so that they can be mapped. So far, enhancement procedures have failed to produce the necessary contrast.

Land Use Studies: The Moorcroft, Wyoming area has been chosen as a comprehensive area for land-use applications of the EREP photography. The area chosen covers approximately 220 square miles. It includes timbered lands, rangelands, farm lands, urban areas, Keyhole reservoir and recreation area, and several clay mines. High quality ERTS, EREP, and aircraft imagery is available for the area. The variety of available data will allow comparitive evaluations of the different platforms and sensing systems as well as evaluations of the EREP photography.

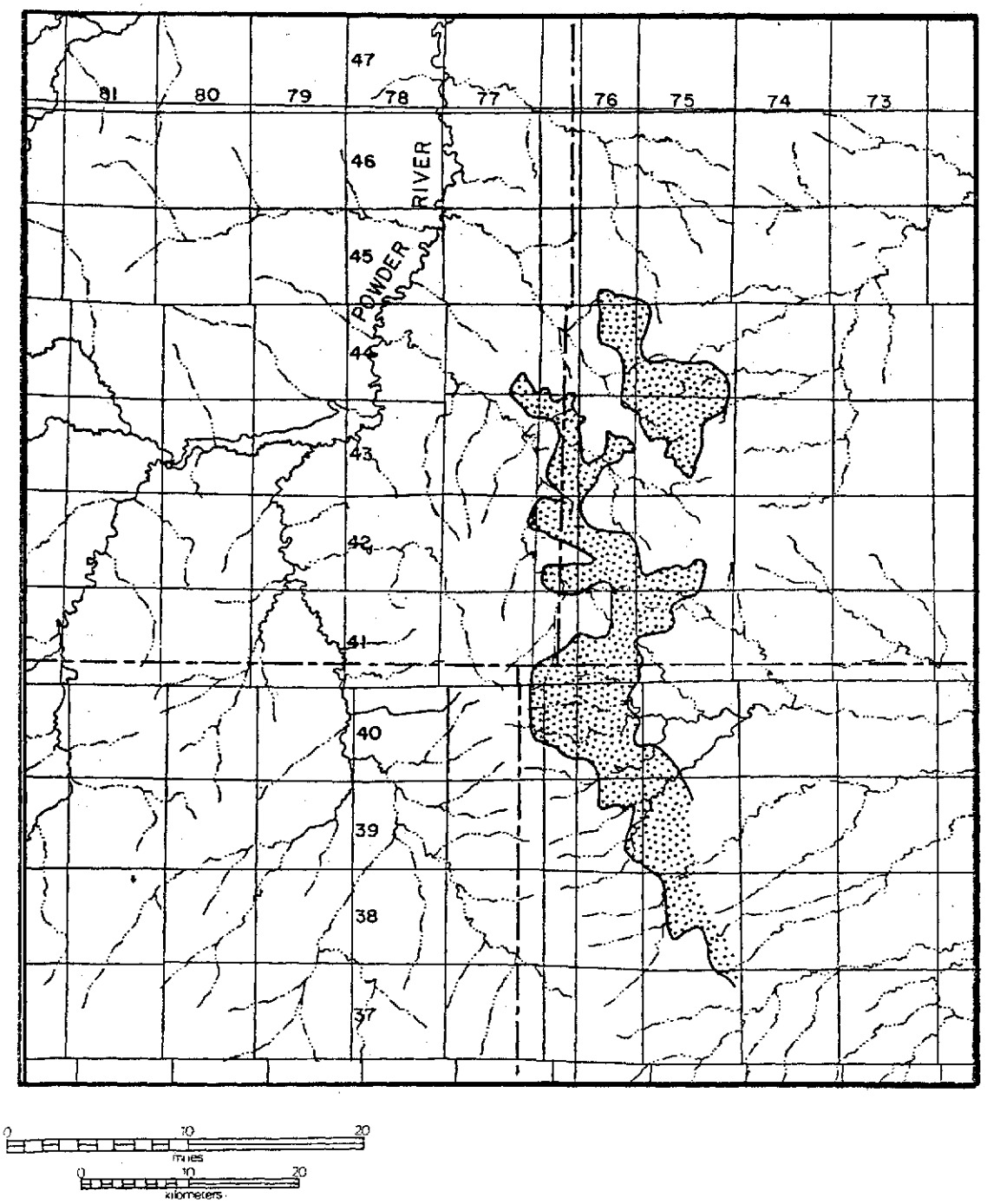

Figure 3. Alteration map interpreted from ERTS-1 color composite image 1047-17182.

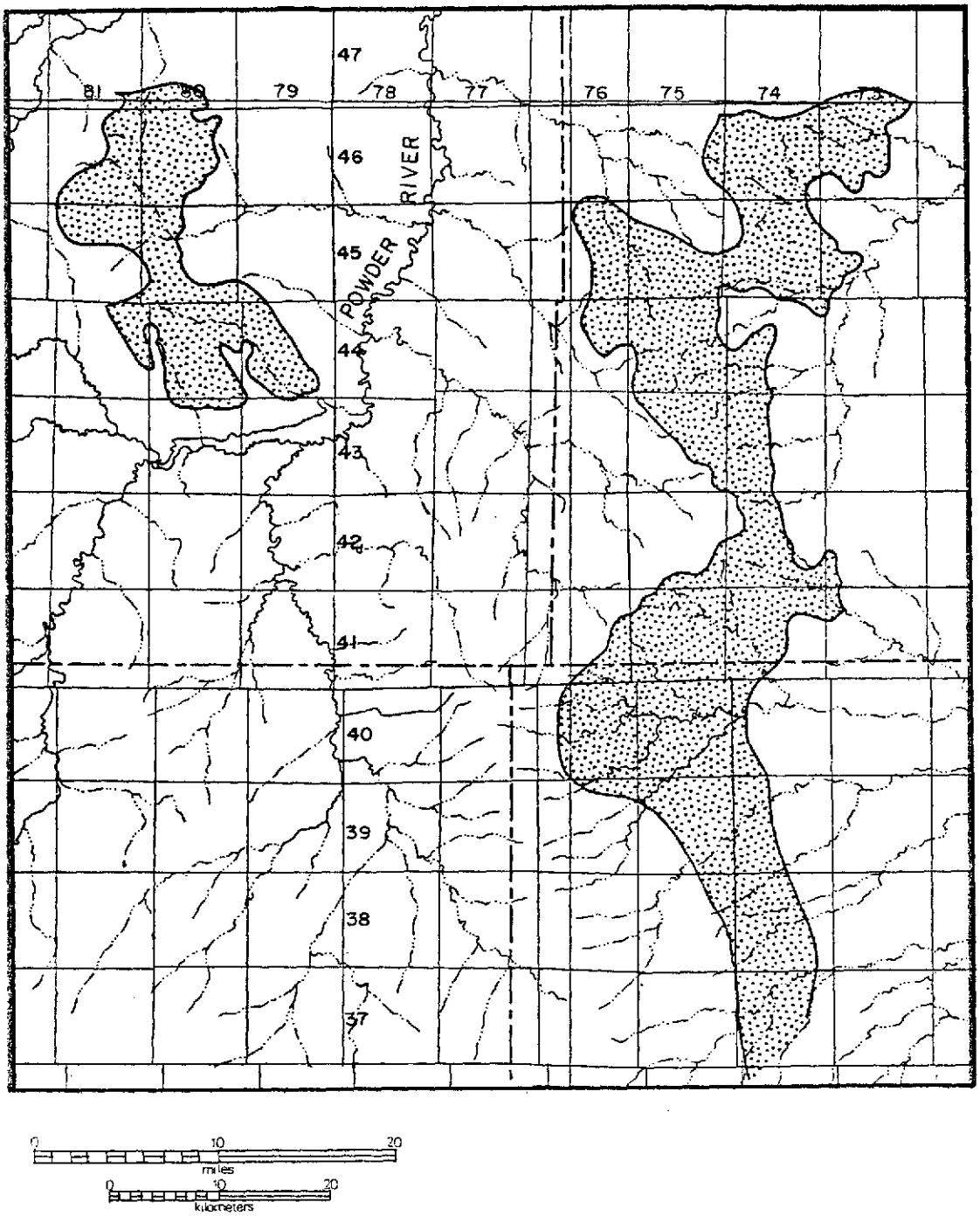

Figure 4. Area of alteration mapped from Skylab S-190B color image 88-020.

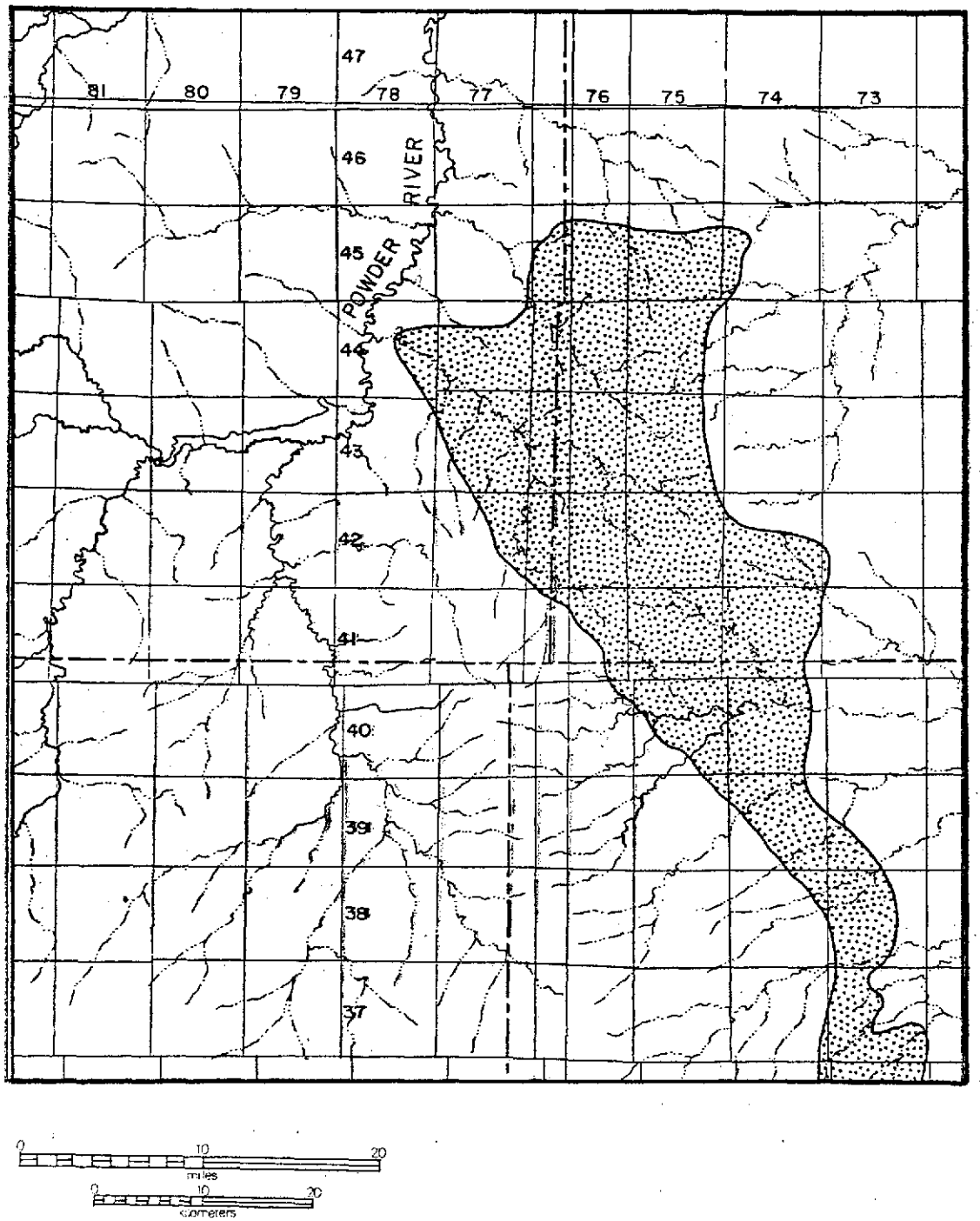

Figure 5. Extent of uranium alteration in the southern Powder River Basin (after Sharp and Gibbons, 1964, plate 3).

Preliminary results of the ERTS, EREP (S-190A) and aircraft (1:120,000) photointerpretations indicate substantial improvement in the land use map with increased resolution. We anticipate the final maps will serve both as a means of qualitative comparison and as a basis for estimating a cost/benefit comparison of the ERTS,EREP and aircraft imagery. The image interpretations will be complete this autumn and winter, with final field checks to be completed in spring and summer, 1975.

Rangeland Mapping: A proposed test to evaluate EREP data for rangeland mapping and estimation of above-ground, green biomass has been substantially altered due to lack of coverage over the selected test site. The Baggs, Wyoming area was initially selected for the test because it was the only site with the necessary background information available. The Baggs site has been used as a test area both prior to and during evaluations of ERTS data. Consequently, records of growth and productivity are available for a period of several years. It would have been an ideal site for direct evaluation of the EREP data and for comparison of EREP with ERTS. The Baggs site was not imaged from Skylab, but a somewhat similar area to the southwest (Pass 8, Track 48) was covered. Investigators are currently relocating range sites and gathering vegetation samples in an effort to gain the basic data necessary for and evaluation of the EREP data in this area. However, the success of the evaluation will be partially dependent upon success in extrapolating growth patterns and biomass/reflectance ratios from the Baggs site to the adjacent EREP test area.

SUMMARY OF SIGNIFICANT RESULTS

Success with early applications of EREP imagery to mapping photolinear elements and analysis of drainage patterns demonstrate the potential of the EREP photography for tectonic studies. A substantial illumination-angle bias was noted in these analysis and subsequent image interpretations have attempted to take this into account. One of the best ways to compensate for this bias is to use information derived from several images taken at different sun azimuths and elevations. In such applications the sun-sunchronous orbit is a definite disadvantage.

In general, geologic mapping EREP photography approaches a happy medium between detail and regional coverage. It provides the synoptic view that is so important in the recognition of regional features and interrelationships while providing much of the detail needed for accurate photogeologic interpretation.

Some success has been achieved in mapping the toxic plant communities and sand/shale facies changes of the Wasatch Formation. Higher resolution is desirable in this application.

PROBLEMS AND RECOMMENDATIONS

Some aspects of the Wyoming EREP investigation have been delayed as a result of delayed receipt of some S-190 photographic products (Table 1). Other studies have been altered to accommodate for lack of appropriate coverage (Baggs site), but the chief problem has been in the delay of processed data products from the S-192 multichannel scanner. Requests for processed S-192 data are still outstanding. We believe that the S-192 scanner data has considerable potential for feature enhancement

and can provide much information not available from the S-190 photographic facilities. We are presently considering alternative means of processing the S-192 data and expect to submit a revised S-192 data request.

Postponment of some EREP studies has precipitated a rather critical situation with regard to field checks. Some tasks that were originally scheduled to be completed and field checked in summer, 1974 were not completed in time to be field checked this summer. Academic responsibilities of the EREP investigators and winter weather may cause some of the field checks to be postponed until spring and summer, 1975.

SUMMARY OUTLOOK

S-190A and S-190B photography has generally exceeded our expectations for general geologic, vegetative, and land-use mapping. Topical applications such as mapping of alteration zones or facies changes have proven marginal by standard photointerpretive techniques. Special enlargements and image enhancement procedures may be effective in these situations. If test areas lacking coverage can be successfully relocated, all investigative objectives involving S-190 data should be reached.

Useful S-191 and S-192 data is not yet available. Applications requiring the use of these data will be postponed until these data are received.

SELECTED REFERENCES

Breckenridge, R. M., and Marrs, R. W., 1973, Cooperative multi-disciplinary proposal to study test sites in Wyoming -- progress report; Dept. of Geology, University of Wyoming, available from National Technical Information Service, Report E73-10552, 6p.

Houston, R. S., and Marrs, R. W., 1974, Use of Skylab S-190A and S-190B photographs in Wyoming earth resources studies, presented before the American Astronautical Society, Aug. 20-22, 1974, University of Southern California, Los Angeles.

Houston, R. S., Marrs, R. W., and Tomes, B. J., 1974, Some illustrations of the advantages of improved resolution in geologic studies; Special Report, Dept. of Geology, University of Wyoming; available from National Technical Information Service, Springfield, Va., 73p.

Love, J. D., Weitz, J. L., and Hose, R. K., 1955, Geologic Map of Wyoming, U.S. Geol. Survey.

Marrs, R. W., 1973a, Multidisciplinary study of Wyoming test sites -- monthly progress report; Dept. of Geology, University of Wyoming, available from National Technical Information Service, Report E73-10697, 6p.

Marrs, R. W., 1973b, Multidisciplinary study of Wyoming test sites -- progress report; Dept. of Geology, University of Wyoming, available from National Technical Information Service, Report E73-11138/wr, 9p.

Marrs, R. W., June 1973c, Multidisciplinary study of Wyoming test sites -- milestone plan; Dept. of Geology, University of Wyoming, available from National Technical Information Service, Springfield, Va., 3p.

Sharp, W. N., and Gibbons, A. B., 1964, Geology and uranium deposits of the southern part of the Powder River Basin, Wyoming; U.S. Geological Survey Bulletin 1147-D, 60p.